Building Research Establishment Digest

CI/SfB 1976 (Ajt)

DIGEST 220

November 1978

Timber fire doors

A well-designed door assembly (leaves, frame, hinges and other door furniture) will fulfil its normal functions of isolation, insulation and security without causing too much hindrance to the movement of people and goods. Delaying the spread of fire and smoke is one important aspect of security.

The precise role to be played by doors in various locations in buildings, the methods of assessing performance and the criteria to be applied are topics under active discussion in this country and abroad. This digest, which can give guidance only of a general nature, reviews the current situation and will be further revised when these activities have resulted in changes in specifications and requirements.
This digest replaces Digest 155 which is now withdrawn.

Fig 1

Different parts of a building may be separated from each other into compartments by a fire-resisting construction; any openings leading to and from them will be closed by doors which will have a precise function to fulfil in case of a fire. First, the door should prevent excessive transmission of products of combustion which can interfere with the safe use of escape routes; second, it should maintain the effectiveness as a fire-barrier of the wall in which it is located. Every fire door is therefore required to act as a barrier to the passage of fire and smoke to varying degrees dependent upon its location in a building and the fire hazard associated with the building or room, bearing in mind its contents, occupants and use.

Functions

The majority of fires start from small sources and develop quantities of smoke in the early stages. There will generally be pressure differences across a door caused either by the wind or by the fire itself. These pressures can act either to force smoke through gaps or cracks in and around the door, or sometimes to oppose its flow. In the absence of effects due to

Prepared at Fire Research Station, Borehamwood, Hertfordshire WD6 2BL
Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

wind or changes in temperature in the fire compartment, the flow into the fire compartment takes the form shown in Fig 2.

A door in the enclosing walls bounding the fire compartment will be subjected to these pressures and smoke will be forced through any gaps. As the fire progresses, there may be some damage to the door which may become deformed and consequently allow greater quantities of smoke to pass through. If the fire becomes large the door is required to withstand exposure to the high temperature conditions without losing its integrity.

The functions of fire doors may therefore be summarised as:

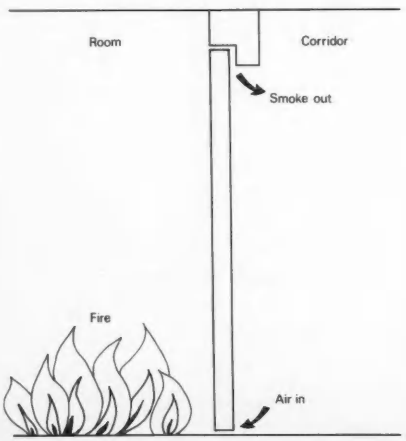
1 To provide adequate resistance to the passage of smoke and other combustion products during the early stages of a fire.

2 To provide a barrier to a well-developed fire without permitting excessive quantities of smoke and hot gases to pass.

Some doors may be required to fulfil only the first function as they may not be subjected to the full severity of a fire because of their location; others may have the main aim of resisting fire penetration as indicated by the second function. Some may have to meet both requirements. At present, fire doors are used as smoke control doors when required to fulfil the first function and fire resisting doors to fulfil the second.

The ability of fire doors to perform their designed function will depend upon their being fully closed at the time of fire; they are, therefore, normally required to be fitted with positive closing devices. Electro-magnetic or similar hold-open devices may sometimes be used which can be released by an automatic detector or alarm signal but any attempt to prevent a door closing by wedges or hooks will have disastrous effects in the event of fire.

Fig 2 Typical movement of air and combustion gases around the edges of a closed door to a room involved in fire (wind and expansion effects ignored)



Assessment of performance

The performance of door assemblies as barriers against the passage of fire, ie fire resistance, is judged by subjecting them to standard heating conditions in a furnace (Fig 3). The current test procedure is specified in BS 476:Part 8:1972 and although this replaced the fire resistance section in BS 476:Part 1:1953, tests carried out under the earlier standard may still be acceptable to many authorities. As Part 8 made a few fundamental changes in the procedure for testing, reference will be made to both parts.

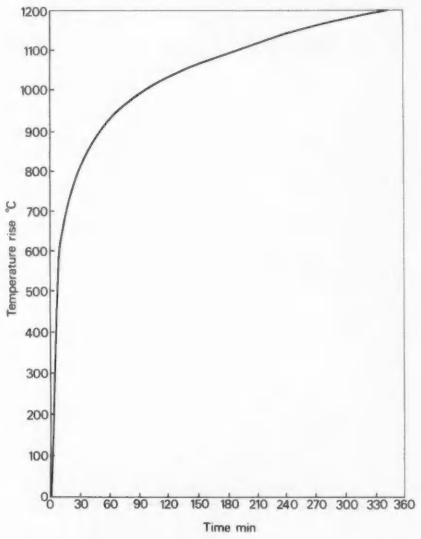


Fig 3 Standard time-temperature curve BS 476:Part 8:1972

Neither Part 8 nor Part 1 specifies how doors should be constructed but both require the specimen door assembly to be representative of the one to be used in practice, including all essential hardware. One of the requirements is that the gap between the door and frame of the assembly to be tested shall not be less than 3 mm unless the gap is controlled in practice (as with a door set). Tests are carried out on a complete door assembly mounted in a wall representing its use in practice (Fig 4). By testing a door in one design of frame and using it in another, no guarantee can be given of its behaviour under fire conditions. The test procedure is fully described in the Standard and consists of exposing one face to the standard heating condition whilst observing the door for the maintenance of stability, integrity and insulation.* Part 8 requires the tests to be carried out with the upper

*Stability: resistance to collapse of the specimen.
Integrity: resistance to penetration of flame or hot gases which can ignite a combustible fibrous pad. Integrity is also lost when spontaneous flaming occurs on the unexposed face (ie the side of the specimen which is not being subjected to the heating conditions of the furnace).
Insulation: resistance to excessive temperature rise on the unexposed face.

part of the door under a small positive pressure, to simulate the conditions likely to occur in a fire. It also provides a more objective method of establishing the loss of integrity of a door by using a combustible fibrous pad; this was previously established by visual observation. Part 1 did not require any measurements to be made of the insulation provided by a door against the transfer of heat.

A door should be tested from each side to establish its performance with either face exposed to fire conditions; this requires two specimens but if it can be established that in practice fire is likely to attack only from a specified direction, only that face needs to be exposed in the test.

An International Organisation for Standardisation (ISO) method of test for the fire resistance of doors is specified in ISO 3008. This standard is similar to ISO 834 for elements of building construction but is designed specifically for doors.

Fire behaviour

On exposure to high temperatures, charring of the exposed face occurs leading to surface ignition. Burning of the timber from the exposed face and the consequent movement of moisture inside the section causes deformation of the door panel (Fig 5).

Timber doors are usually provided with two or three hinges along one vertical edge and a latch at about mid-height along the other. The triangular sections at the top and the bottom of the door are free to deform and the maximum movement is likely to occur at the two corners on the closing edge. If the closing face of the door is exposed to the fire conditions, the stops on the frame will restrain this movement but this will stress the hinges and latch. When the opening face is exposed there is no restraint at the corners which are then free to deform. The gaps between the door edges and the frame provide an area which the flames can exploit and

Fig 5 Deformation of door

the extent of charring is greater than through the solid section. The amount of damage is influenced significantly by the initial size of the gaps, by any increase in gap that may occur by shrinkage and warping of the door and by the flow of hot gases through the gaps.

Gradual deterioration of the door assembly along the edges between the door and frame leads to the transmission of hot gases, widening of gaps, appearance of glowing on the unexposed face (Fig 6) and finally flaming. Initial failure is frequently in the upper half of the door, either along the top edge or the vertical sides close to the hinges. Failure in these areas usually occurs before penetration of fire through the door.

Fig 4 Fire resistance of a door

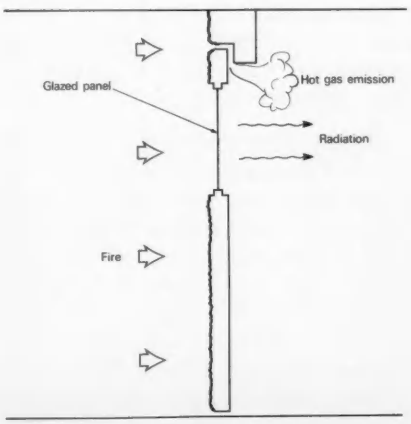
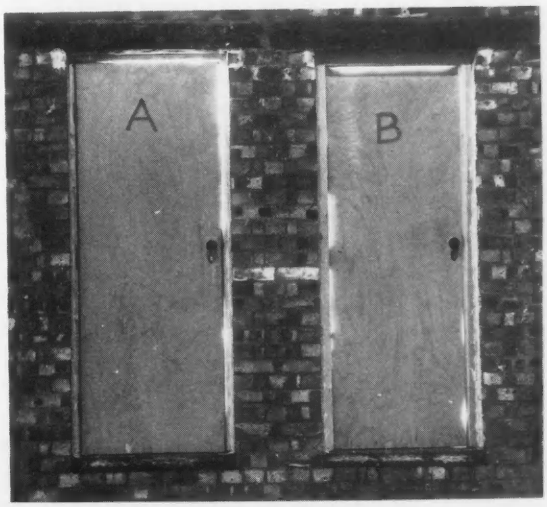


Fig 6 Fire penetration along edges



One technique for minimising the susceptibility of door edges to early penetration by fire consists of applying to the edges special materials having intumescing characteristics so that a rise in temperature will cause the material to swell and close the gaps. Intumescent paints have been used but the most successful and reliable technique is to insert an intumescent device, or to inject paste into a groove cut in the door or the frame edge. As soon as the temperature in the vicinity of the protection exceeds 200°C, usually about 10–15 minutes after the start of the standard test, the intumescent product swells and seals the gap (Fig 7).

For the increased protection needed with one-hour doors, a few of these strips, both in the door and the frame edge, may be necessary. The protection must be continuous and not interrupted at hinges and latch plates. In some methods, certain specific types of intumescent material can be located behind a protective timber veneer.

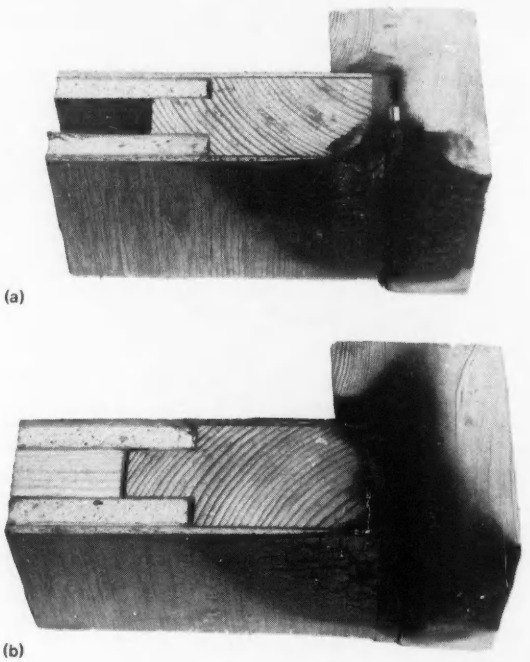


Fig 7 Exposure to fire on door (a) with intumescent strip and (b) without

Specifications

Doors are specified by fire regulations in a number of ways, for example:

Constructional specification	–	The London Building (Constructional) By-Laws 1972
Performance specification	–	The Building Regulations 1976
Type specification	–	British Standard Code of Practice, CP3 Chapter IV

Although BS 476:Part 8 allows door assemblies to be judged by three criteria, stability, integrity and insulation, regulations and codes do not usually require compliance with the insulation requirement. *The performance of a given door assembly can be established categorically only by test, but an assessment may be possible from a close study of the design features.* The data given in this section are intended to highlight the important features and measures that are necessary.

Smoke-control doors

At present there is no standard definition or test method for assessing the performance of doors which are required to restrict the passage of smoke but work is in progress under ISO to define criteria and test procedures which may be used for classification.

Doors which are installed solely to limit the spread of relatively cool smoke within escape routes may need little or no fire resistance and therefore the thickness of the door and type and extent of any glazing may not be critical.

Single swing doors must be close fitting in a rebated frame with 25 mm deep stops so that despite a pressure difference across the two sides only small quantities of smoke will pass. Additional seals must be provided around the edges if stops are smaller. Normal draught excluders can be satisfactory for a time but will not remain effective under fire conditions.

Doors which are required to swing in both directions, such as in corridors and lobbies, and therefore cannot be rebated, are likely to offer less resistance to the passage of smoke. Smoke-resistance can be improved by fitting smoke seals such as felt brush or flexible polyurethane foam; intumescent strips will not become effective until the later stages of a fire.

Fire-resisting doors

The periods of fire resistance which regulations specify, and for which timber fire doors are generally suitable, are listed in Table 1. Those doors which provide a lower integrity than stability are sometimes referred to as fire-check doors but it is preferable to refer to the door's performance for clarity.

Half-hour (30/20) fire-resisting doors The specification which is given in BS 459:Part 3 is widely used and even with doors of a different design it is customary to use the frame specified in the Standard. The doors are 45 mm thick but some 40 mm doors have been proved successful by test; in all cases the frame has 25 mm deep stops which may be glued and pinned or screwed to the frame. The gap between the door edge and the frame should not exceed 3 mm; two or three hinges and a

Table 1 Fire-resisting doors

Door type	Stability *Minutes*	Integrity *Minutes*
Half-hour	30	20
	30	30
One-hour	60	45
	60	60

latch are required to hold the door in the closed position (Fig 8).*

Alternative door constructions which have been shown to provide similar performances are solid timber, compressed straw, extruded chipboard, cork, flaxboard and compressed fibre-board strips.

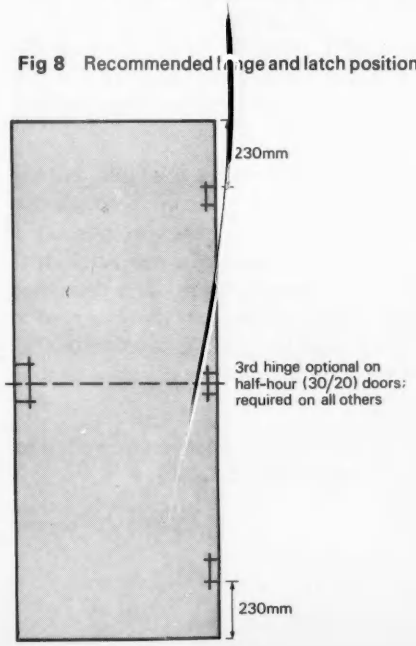
One-hour (60/45) fire-resisting doors A specification is given in BS 459:Part 3 for 54 mm thick doors of composite construction with asbestos board mounted in an impregnated timber frame with 25 mm stops cut from the solid or in a steel frame with 20 mm stops. The gaps between the door edge and the frame should not exceed 3 mm. At least three hinges and a substantial latch and latch plate are needed.*

Other door constructions which have been shown to provide similar performances include blockboard, compressed straw and cork cores with asbestos facings and veneer.

Half-hour (30/30) and one-hour (60/60) fire-resisting doors These doors are based on similar designs to those found satisfactory for the 30/20 and 60/45 situations, but with additional protection to prevent fire penetration at the edges. Few one-hour timber doors are available commercially.

*The performances indicated above for the two types of door construction in BS 459:Part 3 are in relation to the BS 476:Part 1 test procedure. The use of some form of intumescent protection is normally standard practice for all doors now submitted for test and such protection would allow the BS 459: Part 3 doors to satisfy the corresponding criteria under Part 8.

Fig 8 Recommended hinge and latch positions



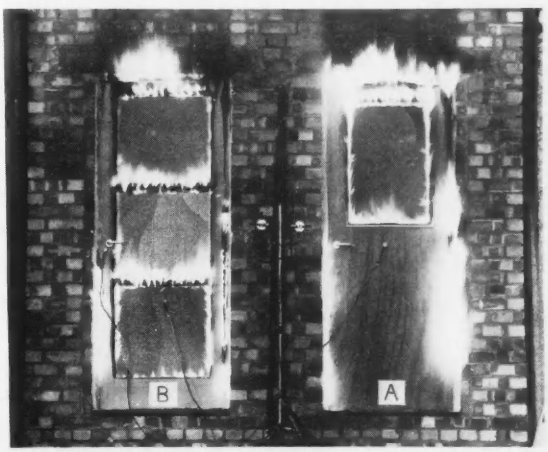
Glazing

Glazing may range from a small vision panel in a door to a hinged, glazed screen for maximum light transmission. Ordinary glass cracks when exposed to heat and is liable to fall out fairly early in a fire. Wired glass 6 mm thick can withstand exposure to the heating condition in a fire test for at least 60 minutes before it reaches a temperature high enough to soften it. The main reason for this is that nearly 50 per cent of the incident heat is transmitted through the glass by radiation.

The size of the glass and the method of its retention are important factors which influence its performance. As the temperature approaches the softening point a large sheet will tend to collapse earlier than a smaller one. On the unexposed face, beading retaining the glass is subjected to radiant and conducted heat through the glass and to convection currents at the top of the pane. This can raise the temperature sufficiently to ignite timber beading after about 20 minutes (Fig 9). To delay the ignition of beading to 30 minutes it is necessary to provide protection by impregnation, surface coating or a surface covering of non-combustible material. For longer periods of fire protection, an improved retention system for the glazing is needed; so far only non-combustible glazing sub-frames have been shown to be satisfactory. The glass panel should be small and the method of fixing it should ensure that no direct path can be created for the transference of hot gases.

The maximum pane sizes given in CP 153:Part 4: 1972 for wired glazing are 1.2 m^2 for timber or metal frames and 0.5 m^2 if the glazing is required to satisfy the integrity requirement of Part 8 for 60 minutes for timber.

Fig 9 Testing fire doors (ignition of glazing beads and door edges)



Fittings and furniture

Hinges and latches have an important role in ensuring the stability of the door. The hinges must remain adequately screwed, in spite of the charring of wood in the vicinity, to provide the necessary fixing to the edge of the door. It is common to use three hinges although tests have shown that with some doors two hinges may be adequate for the half-hour period. Steel and brass hinges are effective for a half-hour door, but only steel hinges are recommended for a one-hour door. For the latter, it may be necessary to use hinges with extended flaps (broad butts) so that fixing is maintained even when severe charring has taken place.

The latch is the only holding device on the closing edge, and so it is important that it should be strong and that the nib of the latch should engage into the latch plate at least 10 mm to ensure that the closing edge will not spring open when the door deforms. Cranked-flap latch plates are advisable for one-hour doors. Where mortice locks are provided, the cut-out in the door should be the minimum necessary to prevent any voids which fire can penetrate. After the edges, the mortice lock and latch areas represent the next zone of weakness. Filling the voids in the cut-out with intumescent paste will markedly lessen the weakness in this area.

Plastics and aluminium handles and knobs will be destroyed on the fire side but this may not have a serious effect on the integrity of the door if steel spindles are provided. Letter plates introduce a weakness in a door and should ideally be positioned in the lower part of the door. Letter plates made of aluminium are likely to melt within the half-hour period of the test and a steel flap may be necessary on the inside of the door to maintain integrity.

Self-closing devices can suffer damage and consequently become inoperative if they are surface mounted on the exposed face. If their sole function is to close the door with a latch, when they have done so any damage suffered need not be critical for the integrity of the door. Recessed self-closing devices will suffer less damage, but can produce a local weakness if fitted in the top of the door leaf. The ideal place is within the sill where it will cause the least interference with the performance of the door. The Building Regulations set out the circumstances in which rising butts may be used: where they are fitted, compensation must be provided for the cut-out from the top edge of the door by increasing the depth of the stop (Fig 10).

A self-closing device used with double swing doors, or any door not fitted with a latch, should not only close the door leaf but also hold it firmly in the closed position. It needs to be strong enough to keep the door leaf closed against any pressure to which it may be subjected in a fire, and be so designed and fixed that it continues to function even though subjected to high temperatures.

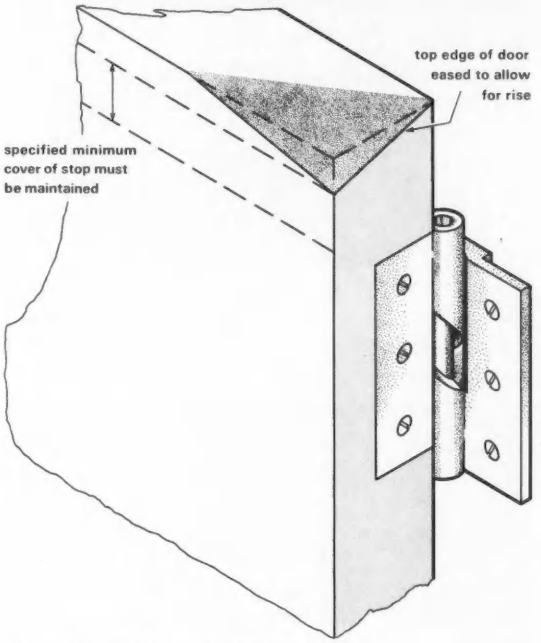


Fig 10 Rising butts need a deeper head stop

Existing doors

Occasionally it is necessary to improve the performance of an existing door to a half-hour 30/20 or 30/30 standard, although in practice it may be more economic to replace the door rather than alter it.

Panelled doors having stiles and rails not less than 37 mm in thickness are generally suitable for upgrading; flush doors need to have a substantial sub-frame and unless the precise specification of a flush door is known, it is difficult to be sure about its suitability for upgrading.

Various methods of upgrading are available, but for any system involving the use of board materials the importance of fixing cannot be over-emphasised if the additional protection is to be of value. Additional materials must be so fixed to the existing door that under conditions of fire, where thermal movement is likely to take place between the door and protective material, the screws or nails are not stressed so that they are pulled out.

Existing door assemblies can seldom be upgraded to a higher standard than 30/20 or 30/30.

British Standards

BS 459:Part 3:1951 Fire-check flush doors and wood and metal frames (half-hour and one-hour types)

BS 476 Fire tests on building materials and structures
- Part 1:1953 Fire tests on building materials and structures
- Part 8:1972 Test methods and criteria for the fire resistance of elements of building construction

CP 153 Windows and rooflights: Part 4:1972 Fire hazards associated with glazing in buildings.

CP 3 Code of basic data for the design of buildings: Chapter IV: Precautions against fire
- Part 1:1971 Flats and maisonettes (in blocks over two storeys)
- Part 2:1968 Shops and department stores
- Part 3:1968 Office buildings

Department of the Environment **Building Research Establishment**

© *Crown Copyright 1978*

Published by Her Majesty's Stationery Office and printed in England by Waterlow.
Single copies 12p each. Annual subscription inclusive of postage £2.28 for 12 monthly issues and new editions of earlier Digests.
Quantity rate (excluding postage) for bulk supply of any one Digest: 50 for £4.80

Dmd. 586152 ISBN 0 11 724 148 2